CHAPTER 4

Beam Manipulation Systems

What is a beam manipulation device? It is any component, other than the main dipoles and quadrupoles, that bends, focuses, separates, collimates, kicks, or in any other way intentionally affects the beam for some given purpose.

Dipole Correction Elements

The correction element dipoles are strong enough to steer beam at any energy. The correctors have a current range of +/-50 A. They are powered by a raw bulk supply per service building, which feeds one regulator per dipole. The regulators are driven by a programmed low level curve from a CAMAC 460 module, also known as a dipole function generator (DFG).

The C460 module is a programmable ramp controller whose functionality mirrors that of the C46x family and is capable of generating an analog waveform which is based on the time in the cycle, current (MDAT value), and change in current (MDAT value). The time portion of the waveform is updated at a 1 KHz rate, and the MDAT portion is updated at a 720 Hz rate. The C460 also contains digital control capabilities to turn on, turn off, and reset a power supply. It can also return sixteen status bits from the power supply.

Each DFG receives a digital number via the CAMAC 169 card in slot 1 of the DFG crate. The C169 card is a single wide CAMAC card that receives the serial information from the MDAT link, converts it to a parallel format, and daisy chains out to the C460 cards.

The regulators contain circuitry for protection of the magnets against ground faults, quenches, and protection of the regulator circuits against loss of water or over-temperature.

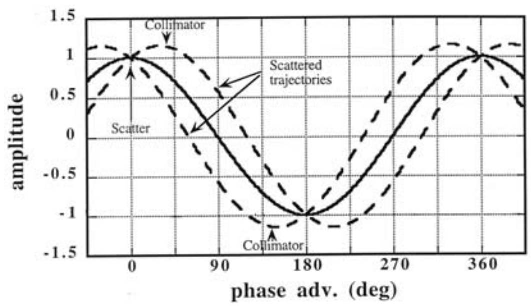
Higher Order Correction Elements

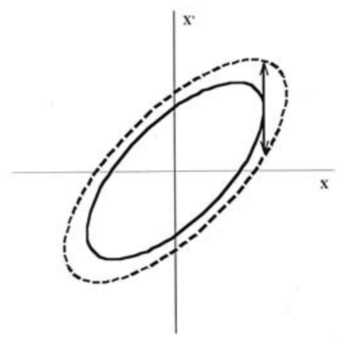
Separators

Collimators

Whenever proton and antiproton beams are injected into the TeV and ramped to 980 GeV they will always have a distribution of particles with some residing at lower and higher energies from the desired energy.

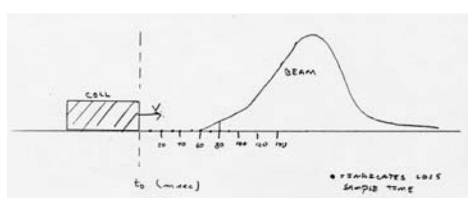
A finite fraction of the beam will move beyond the stable phase space separatrix due to possible beam-gas interactions, intra-beam scattering, proton-pbar interactions at the interaction points inside the detectors, RF noise, ground motion, and resonances excited by magnet imperfections. These particles produce a beam halo, which can interact with the beam pipe to create electromagnetic and hadronic showers in the accelerator and detectors causing a higher background level at the interaction regions.





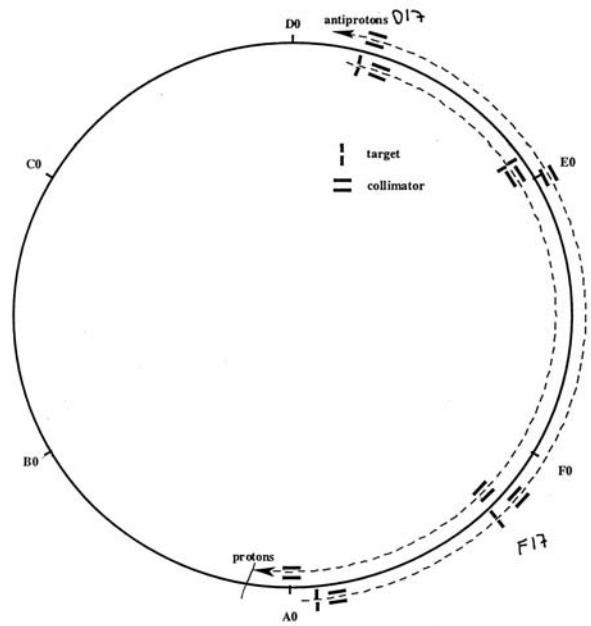
The collimator system localizes most of the losses in the straight sections D17, D49, E0, F17, F48, F49, and A0. The system consists of horizontal and vertical primary collimators and a set of secondary collimators placed at a desired phase advance so it can intercept most of the out-scattered particles during the first turn after interaction with the primary collimators.

The primary collimator, often called the target, consists of a movable, narrow Tungsten target 5mm thick and the secondary collimator is a 1.5 m long stainless steel absorber. The target moves into the beam pipe about 5 σ from the beam axis and the secondary collimator moves in about 7 or 8 σ from the beam axis.

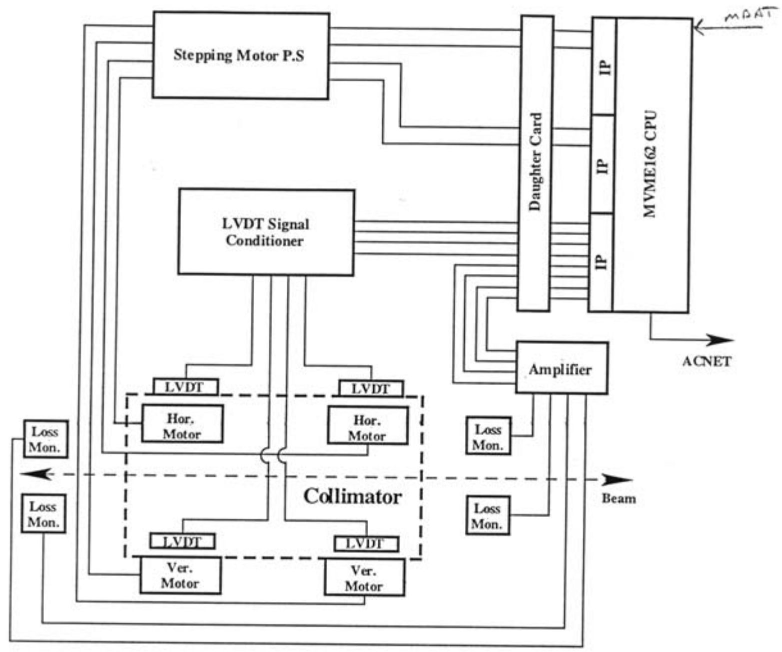


Equipment and control

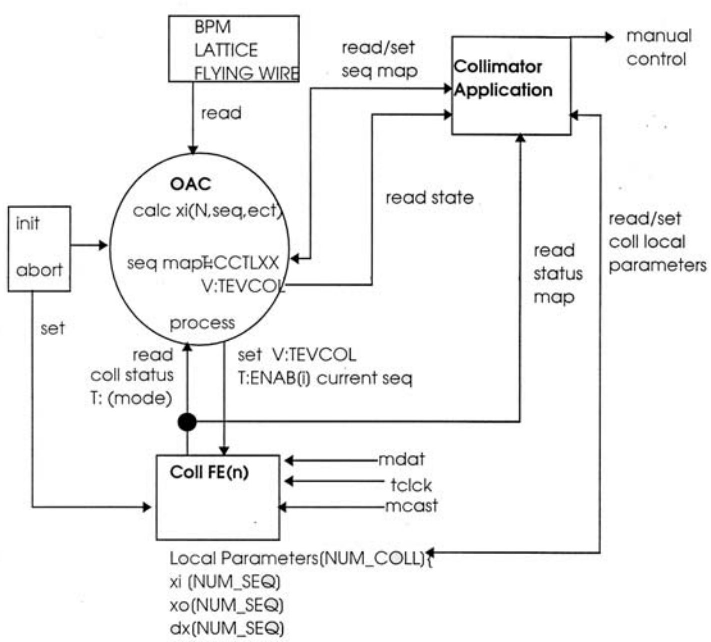
The map below shows the location of the primary and secondary collimators around the ring. In Run Ib the typical scraping procedure took about 20 minutes to complete. The Run II system is automated. There are 4 sets of collimator systems for scraping away the halo, 2 are for proton removal and 2 are for pbar removal. A 5th collimator system at E0 is for proton removal after a store so that pbars can be recycled for future stores.



Each collimator is controlled by a local processor running VXWORKS in a VME crate. The targets have a single motor for the vertical motion and a single motor for the horizontal motion. Secondary collimators have 2 motors in each transverse dimension to control upstream and downstream motion independently. The stepping motors are geared so that the collimator can be moved 1” in 13 seconds, which is the full distance from the out position to the beam axis. Position readbacks are provided by LVDT’s (Linear Variable Differential Transformers); 4 per secondary collimator, 2 per target collimator. Limit switches protect the hardware from damage. Local feedback for the motion control, operating at 720Hz in the CPU, is provided by 4 standard TeV BLM’s – 2 upstream and 2 downstream for redundancy. Stepping motors, loss monitors, and LVDT’s are interfaced to the CPU via 3 IP’s (Industrial Packs). Communication with ACNET is through Ethernet. A single VME crate can house multiple collimator systems.



The beam halo scraping sequence is controlled by an application program that initiates motion for each collimator, waits for a completion status from that collimator, and initiates the next collimator move. The application program communicates with an Open Access Client (OAC) that runs the algorithm for stepping the collimators in/out of the beam path. The collimator move commands are sent to the Collimator front end, which loads the commands into the local VME's.



How halo is removed

Proton Removal for Recycling pbars

Kickers

The Tevatron uses kickers for injection of protons and pbars and also for sending beam to the A0 abort. The proton injection kicker is located at F17 and the pbar injection kicker is at E48. Both are short batch kickers and have a rise time of 396 ns, which is the spacing between bunches. These kickers must maintain a 1.21 microsecond flattop and 2.61 microsecond fall time.

Electron Lens